Synchrotron White Beam X-ray Topography of the Surface of an As-Grown Langatate Boule

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Beamline(s): **X19C**

Introduction: Langatate (LGT - $La_3Ga_{5.5}Ta_{0.5}O_{14}$) belongs to a new class of piezoelectric oxide materials having the same structure as calcium-gallium-germanium garnet (CGGG). These materials are based on langasite (LGS - $La_3Ga_5SiO_{14}$) which possesses properties such as temperature compensation near room temperature and adequate electromechanical coupling constant as well as low acoustic friction (high Q factor). Substitution of Ta in langatate shows increased piezoelectric effect due to the strong polarizability of the Ta ion in the distorted octahedral site of CGGG crystal structure (space group P321). These crystals melt near congruently (1470°C) and hence, they can be grown directly from the melt by the conventional Czochralski pulling method.

X-ray topography of the surface of an as-grown boule is important because it enables one to observe the true microstructure developed during the growth process, with no possibility of artifacts, for example due to polishing or cutting, to exist.

Methods and Materials: A single crystal boule of LGT was grown by the Czochraksi method. Figure 1 shows the optical photograph of the as-grown boule. SWBXT was used to image the surface of the boule in the reflection geometry. A series of x-ray topographs were obtained by rotating the boule about its axis through 360°. The topographs were compared with the optical pictures in order to isolate diffraction contrast from contrast produced by surface features.

Results: The as-grown boule has a somewhat elliptical cross section. The cylindrical surface contains two antipodal sets of (0001) facets running along the length of the boule (Fig.1). Surface is characterized by wavy ridge-like features. Numerous pin sized holes are also observed in some regions. Figure 2 shows a reflection x-ray topograph recorded from the facet region. Well defined striations running perpendicular to the growth direction are clearly visible. Because of the reflection geometry, the x-ray beam is blocked by the facet steps in some regions resulting in white contrast. Similar effects are also observed in the area surrounding the pin sized holes. At the tail end of the boule, numerous precipitates are observed that could have been formed at the end of growth. Precipitates are also observed in the middle sections of the boule in other parts of the boule (Fig. 3). Contrast from the wavy ridge like features on the surface is also observed.

Figure 1. Optical picture from as-grown LGT boule showing (0001) facets (F) and wavy ridge like features (S).

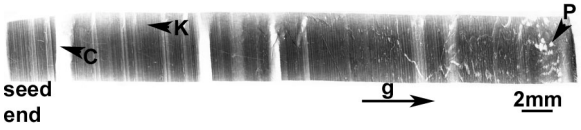

Figure 2. X-ray topograph recorded from the facet region showing striations (K) and precipitates (P) at the tail end. White region C is caused by x-ray beam being blocked by facet steps resulting in no contrast.

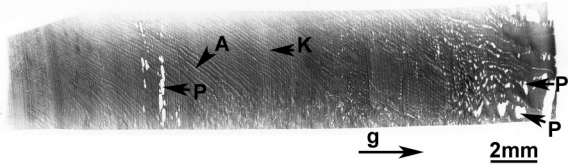

Figure 3. X-ray topograph recorded from the surface showing striations (K), precipitates (P) at both the middle sections and the tail end and contrast from surface wavy ridge like features (A).

Conclusions: Surface x-ray topography of the LGT boule was successfully carried out by SWBXT. Defects such as striations and precipitates were observed. Topographs are dominated by contrast related to surface features.

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